ROBOTICS SCIENCE AND SYSTEMS

TECHNISCHE UNIVERSITÄT CHEMNITZ

On the Potential of Visual Place Recognition for Visual SLAM

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Visual SLAM (V-SLAM)

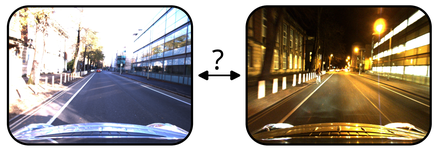
Camera-based localization and mapping

- Combination of
  - Odometry
  - Loop closure detection
    - Essential for globally consistent maps
  - Optimization
- Active research area
- **Research on V-SLAM hardly focuses on loop closure detection**

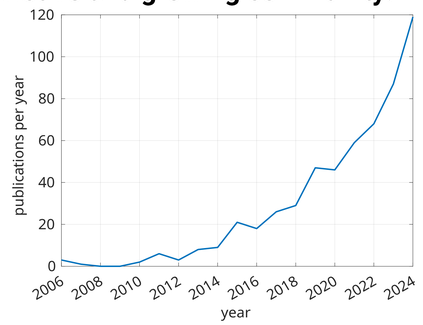
Visual Place Recognition (VPR)

Camera-based recognition of same places

- Key component of loop closure detection
- Often addresses challenging environments
- Active research area with many directions



Active and growing community:



Learn more or discuss further?

1) **See my poster and paper:**
   https://visual-slam-lab.github.io/unifying-visual-slam

2) **Write me an Email:**
   stefan.schubert@etit.tu-chemnitz.de

3) **Feel free to talk with me anytime during RSS!**

Potential #1: The gap between VPR literature and VPR in V-SLAM systems

Rich literature on VPR with many directions

- Local and holistic image descriptors
- Hierarchical VPR
- Descriptor aggregation
- Descriptor transformations
- Sequence-based methods
- Multi-process fusion
- Efficient comparison of descriptors
- Place-specific descriptors or classifiers
- Image translation

Often addresses problems for real-world application

- Large-scale environments (10km to 100km)
- Challenging conditions (e.g., winter, night)
- Changing conditions (e.g., day to night)

VPR pipelines for loop closure detection in recent V-SLAM systems

- Most use hierarchical VPR, but with hand-crafted local descriptors (e.g., ORB from 2011)
- Most use descriptor aggregation with DBoW2 from 2012 or ASMK from 2013
- Some use sequence-based methods, but with DBoW2 from 2012

V-SLAM	Year	VPR System
AirSLAM	2025	PLNet point + DBoW2 + custom geometric consistency check
Basalt	2019	implicitly using ORB and keypoint matching
DPV-SLAM++	2024	ORB + DBoW2 and proximity
DROID-SLAM	2021	exhaustive computation of reprojection error between every frame
GS SLAM	2024	(no loop closure detection)
Kimera	2020	ORB + DBoW2 + geometric verification
MASt3R-SLAM	2024	MASt3R-encoder + ASMK
ORB-SLAM2	2017	ORB + DBoW2
ORB-SLAM3	2021	ORB + DBoW2 with custom geometric and temporal consistency check
SuperVINS	2025	SuperPoint + DBoW3
VINS-Mono	2018	Shi-Tomasi Corner Detector + BRIEF + DBoW2

Key Takeaways

1) VPR has a rich and diverse literature across many method types.

2) VPR tackles a range of real-world challenges.

3) V-SLAM uses only a small subset of existing VPR methods.

4) Many V-SLAM systems rely on outdated VPR techniques.

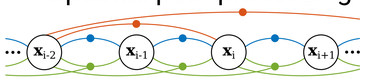
Using more modern and diverse VPR methods in V-SLAM could improve performance.

Potential #2: Correlation between performances of VPR and V-SLAM in a preliminary experiment

Experimental setup

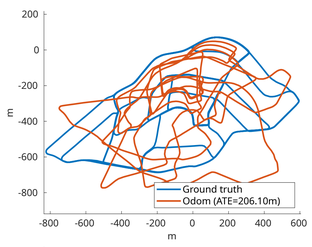
- Dataset
  - Five traversals from St Lucia (multiple times of day)
  - Sensors: camera, GPS
  - Odometry: GPS with 10% noise

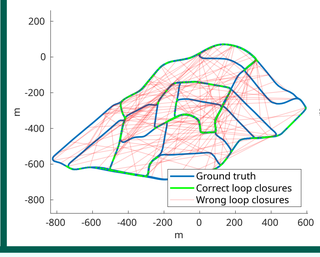
- V-SLAM pipeline
  - Pose-graph with Gaussian max mixture model
  - VPR with six holistic or three local image descriptors
    - Optional post-processing with sequence method

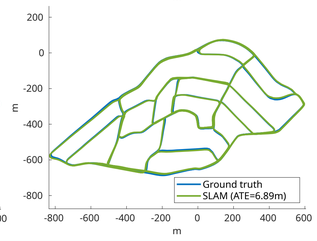


Qualitative results

- Odometry
- Detected loops using best match per query
- V-SLAM result

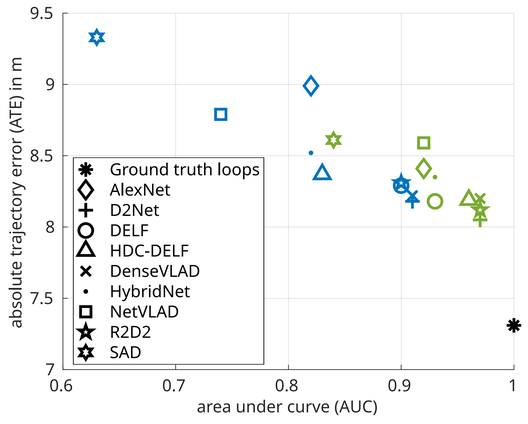






Quantitative results

- Without and with sequence method



Key Takeaways

1) Robust graph optimization can tolerate false-positive loop closures.

2) The performance of VPR and V-SLAM are strongly correlated.

3) VPR methods beyond just descriptors can further enhance results.

Improving VPR potentially leads to better V-SLAM performance.